FLUIDOTHERAPY®

SERVICE MANUAL

All Models

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I. INTRODUCTION

A. Physical and Engineering Principles

In a Fluidotherapy unit, an air-fluidized solid medium is formed by uniformly distributing air through the bottom of a bed of finely divided particles. The resulting state, termed fluidization, is established by the particles becoming microscopically separated from each other by the rising gas. This "fluidized bed" of particles has unusual properties which differ markedly from either those of the gas or of the particles. The fluidized bed behaves like a low viscosity fluid, exhibiting characteristics which are generally attributable to a liquid state.

This property permits submergence of parts of the body into the fluidized bed and the suspension of these parts is very much like a liquid phase. The patient can exercise in the bath almost as freely as in water and can perform a variety of resistive exercises.

B. Principles of Operation

Figure 1 illustrates the general principles of Fluidotherapy unit operation. Control panel (A) contains the electronic circuits which control the speed of the blower (B) and the output of the heater (C). Bed temperature is sensed and controlled by thermistors (D) and (E). One of the temperature sensors measures temperature, the other controls it. (F) and (G) are the top and side entrances, respectively. Air enters through filter (H) then flows through the blower (B) and over heater (C) into plenum chamber (I). Heated air then flows through foam distributor (J) into the bed of finely divided Cellex^{R} particles (K). The foam distributor is sandwiched between two perforated metal plates, and a third plate (L) is there to prevent the patient from contacting the temperature sensors. Wooden supports (M) are used to hold the distributor and plates in place.

C. Control Principles

For proper operation, it is necessary to control the airflow, and the temperature in the treatment chamber. In additionto basic controls, safety provisions must be incorporated as well. In particular, one must guard against the bed temperature being too high, and against the heater being on without air flow. Over the years, various controllers and control schemes have been employed.

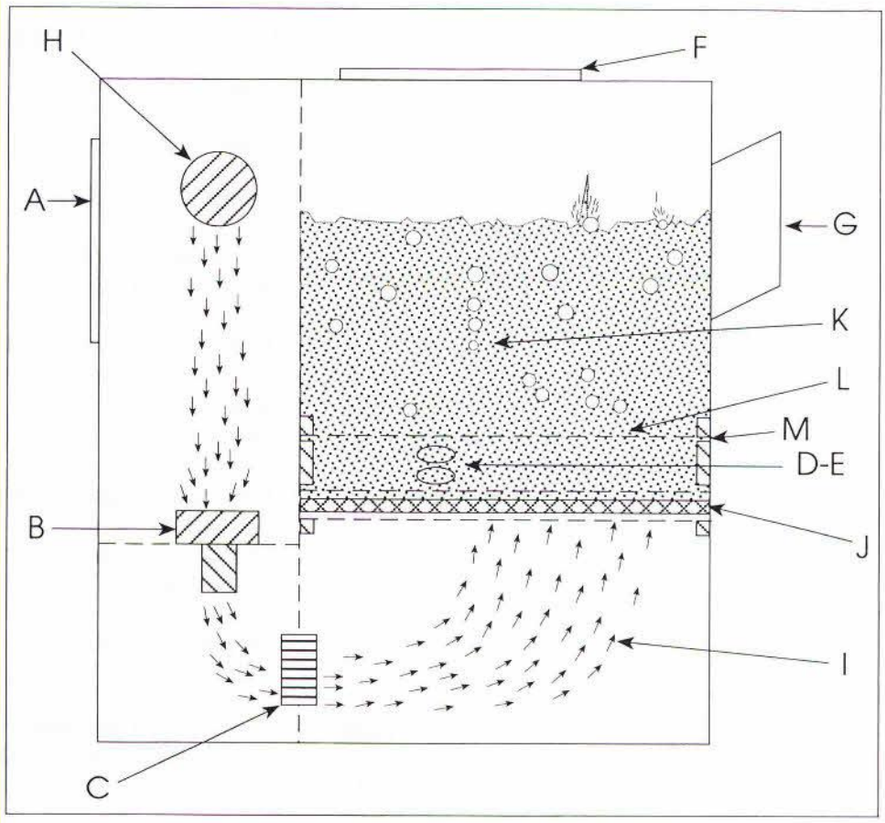

Figure 1
Cross sectional view of a typical fluidotherapy unit.

	Motor Control	Heater Control	Timer	Safety features
1973-1978	Dayton Model 4X797	(On-Off) Fenwall Thermostat	Dayton Model 2E270B	Snap-Disc Thermostat, Grainger 2 E634 (in bed)
1978-1982	Low Hysteresis Triac Circuit	Duty-cycle Modulated Control	Dayton Model 2E270B	Temperature-sensing thermistor cuts off heater if bed is above 140°F. Low-current sensing circuit on motor controller which cuts off heater at low motor current.
1982-1985	Low Hysteresis Triac Circuit	Duty-cycle Modulated Control	Electronic Module (button control)	Snap-Disc Thermostat located at heater. Circuit to prevent blower from being turned completely off when heater is on.
1985-	Low Hysteresis Triac Circuit	Duty-cycle Modulated Control	Electronic Module (membrane switches)	Snap-Disc Thermostat at heater. Circuit to prevent blower from being turned completely off when heater is on. Pressure sensor which cuts off power if pressure under blower falls to ambient.
Other Changes 1973-1986	Until 1978, solder connections were employed. From 1978 to 1985, spade connectors were used. Since 1986, modular connectors have been employed.			

II. TYPICAL SERVICE PROBLEMS

Note: *Causes are not listed by probability or priority.*

A. Loss of Fluidization (Low Air Flow)

Causes:
1. Air inlet filter is clogged.
2. Blower motor (or motor brushes) worn out.
3. Leakage of air from high to low pressure area (out the bottom or around motor gasket).
4. Motor control circuit failure.
5. One motor out on double motor unit.
6. No power to unit.

Note: *Unless there is good fluidization (mixing) erratic temperature readings and control actions will occur.*

B. Uneven Fluidization

Causes:
1. Hole in distributor or distributor not sealed around edges.(This will cause spouting.)
2. Unit not level.
3. Pressure imbalance.

C. Loss of Temperature Control (Unit too hot or too cool)

Causes: Depends on the symptoms. *See section III.*

D. Cellex Spillage

Causes:
1. Improper usage.
2. Improper sleeve fixation.
3. Poor fit or distortion of sleeve.

III. TROUBLE SHOOTING

When receiving a service call, it is useful to ascertain:

1. If the LED display is functioning (this means the unit has power).
2. That there is good fluidization (because poor temperature control can be caused by poor fluidization).
3. How long they have had the unit, and how long since the last service (under heavy use, motor brushes will wear out in about one year).
4. That the air filters are clean.
5. That the unit is at steady state (because transients can occur during warmup).

Some typical scenarios, and diagnoses are:

A. PROBLEM: ***Unit is too hot, and won't cool down***

Condition: Lowest temperature is 105°F (with heater off)
Diagnosis: There is nothing wrong. Motor heat alone can account for this. Use at lower motor setting in cooler room, if temperature below 105°F is required.

Condition: Lowest temperature is about 110°F (with heater off)
Possible Diagnosis: Inlet air screen dirty
Leak (recycle) around motor
Too hot in room
Motor almost worn out

Condition: Lowest temperature above 120°F (with heater off)
Possible Diagnosis: Wrong temperature reading
Same as 110°F diagnoses
Heater light burned out

Condition: Temperature above 110°F, heater light won't go out
Possible Diagnosis: Controller out of calibration
Bad temperature sensor (verify by switching temperature sensor)
LM324 or SC150D Triacs have failed
IC #2

B. PROBLEM: ***Unit will not heat above about 107°F***

Condition: Heater light not on
Possible Diagnoses: (Post 1985 Model) Pressure sensor safety switch failed or has been disconnected.
Temperature sensor failure
Control circuit calibration incorrect
(Post 1982 Models) Low-current cutoff circuit on motor failed

Condition: Heater light on
Possible Diagnoses: Heater failure
Thermal snap-disc failure
Fuse failure
Fuse holder broken

C. **PROBLEM:** *Digital readout temperature is different from bed temperature*

Condition: Bed temperature was measured with thermometer
Possible Diagnoses: Most thermometers are only accurate to 2-3°F, also the temperature measured depends on the depth of immersion. If the discrepancy is more than 5%, verify by limb immersion, and recalibrate.

D. **PROBLEM:** *Controller set at, for example 115°F, but readout shows different temperature*

Condition: Small, or large temperature offsets
Diagnoses: Recalibration required

E. **PROBLEM:** *No fluidization--motor off*

Condition: Power to motor
Possible Diagnoses: Motor brushes worn
Poor connection of motor wires

Condition: No power to motor
Possible Diagnoses: Motor fuse
Motor controller failure

F. **PROBLEM:** *Low fluidization*

Condition: Motor is good
Possible Diagnoses: Air leak in bottom of unit or around motor
Adjustable resistor in motor circuit too high--See II. A.

G. **PROBLEM:** *Uneven distribution or spouting*

Condition: High motor speed
Possible Diagnoses: Distributor needs to be resealed
Airflow must be adjusted--See II. B.

IV. RECOMMENDED TOOL KIT

1. Phillips screw driver
2. Very small, slottedscrew driver (for trim pot adjustments)
3. Allen wrench (.050" size for removing knobs on faceplate)
4. Digital multimeter (amps, volts, ohms)
5. Adjustable wrench (or wrench set)
6. Wire cutter, crimper, stripper
7. Fuses-15A, 120V
8. Silicone
9. Thermometer
10. Knife and/or scissors
11. Camper tape, masking tape
12. Motor brushes, gasket, motor

V. HEATER AND BLOWER SPECIFICATIONS

Heaters for Models 110, 111, 113, 114, 210, 220.
'Finstrip' air heaters, 900 watts @ 120 volts.

Heater for Model 211M.
'Finstrip' heater, 1900 watts @ 240 volts.

Blower motor for Models 110, 111, 113, 114, 115, 210, 220.
Lamb #116309-00 1 stage, Flo-through, roughly 90 cubic feet per minute thru 2 inch orifice.

Blowers for Model 211M.
Lamb #116312.00, roughly 115 cubic feet per minute thru a 2 inch orifice. Three motors required for Model 211M.

VI. REPLACING MOTORS AND HEATERS

WARNING:
Unplug the unit before any service work.
Turning the unit off will not insure your safety.

Motors: To access the motor, remove the screws attaching faceplate to cabinet. Motors are located behind faceplate. Remove motor bracket above motors. Pull motor from mounting hole and unplug connectors on wires.

Connect new motor wires into connectors. Put the gaskets in place in motor housing and install motor in mounting hole. Make sure motor is centered in mounting hole and replace motor bracket. Test motors for air leaks and adjust gaskets if necessary.

Heater--Wood Units: To access the heater, turn unit on its side opposite power cord and remove the bottom. Heater is located in metal air duct secured by two screws. After mounting, make sure heater does not touch cabinet wall. Replace bottom and check for air leaks.

Fiberglass units should be returned to factory for heater replacement.

VII. INSTRUCTIONS FOR MOUNTING NEW CONTROLLER —

STEP 1	Unplug unit from AC outlet.
STEP 2	Remove screws from faceplate, then remove faceplate. Place a box, stool, or small table under faceplate to rest controller on.
STEP 3	Remove each of the wires and cables from board, one at a time. Label each as you take it off. You should now be able to remove the old controller from the unit. Remove original controller from faceplate. Replace with new controller.
STEP 4	Reconnect each of the cables and wires to the new controller. *NOTE: A Polaroid picture can also help if used in conjunction with wire labels.*

The new controller is now hooked-up, and must be calibrated. The calibration procedure follows:

STEP 1	Place controller on a box, stool, or small table so that you can access both the controls, and the circuit board. Be sure that no wires can short circuit against the p.c. board.
STEP 2	Turn blower control knob to low position (faceplate, counter-clockwise). Turn TEMPERATURE CONTROL knob to 115° (faceplate, straight up).
STEP 3	Place thermometer into the treatment bed of the unit.
STEP 4	Plug in the unit. Push treatment button. Turn blower control up to give good fluidization. Unit should now be on and running.
STEP 5	Allow the unit to run until it reaches 115°, as measured with the thermometer. Adjust trim pot R20 on p.c. board until the heater light is flashing on and off (about 50% on, 50% off). The heater is on when the light is on.
STEP 6	Allow the unit to run for about 10 minutes more, then check bed temperature with the thermometer. If the temperature is above 115°, adjust trim pot R20 so that the heater light is on for a slightly shorter duration; if the temperature is below 115°, adjust trim pot R20 so that the heater light is on for a slightly longer duration. Repeat STEP 6, until the unit remains at 115° for at least ten minutes.

At this point, the temperature controller has been calibrated, and all that remains is to calibrate the digital temperature readout.

The unit should still be running, and the bed temperature should be 115 degrees. The procedure follows:

STEP 1	Adjust trim pot on Module A (see Figure 3) until the readout (on Controller) shows '115'. This should be the temperature measured with the thermometer.
STEP 2	Put some nail polish, or glyptol on the trim pots to prevent the vibration from slowly turning the trim pots.
STEP 3	Reattach faceplate to cabinet.

VIII. CONTROLLER DESIGN CRITERIA

A. Temperature control over the range: $105^{o}F < T < 130^{o}F$.

B. Air flow: This is controllable over the range from minimal fluidization volume flow, to the maximum required for violent bed activity.

C. Bed temperature measurement: The measuring system measures and digitally displays bed temperature over the range from $100^{o}F$ to $130^{o}F$.

D. Heater shut-down: The heaters are disabled in case of insufficient bed fluidization.

THE OVERALL SYSTEM

Figure 2 shows the block diagram of the final system. The motor control circuit is a separate block of the system. Its output is a phase-controlled AC voltage applied to the motor.

The heater control circuit has a pair of *control switches. One control switch* maintains temperature by switching the heaters on and off with a variable duty cycle, with a fixed time recycle period. The other part of the circuit acts as a safety switch, shutting down the heaters in the event of inadequate bed air flow.

The circuitry which acts as a feedback temperature controller is composed of a temperature dependent current source, with an associated amplifier, whose output controls a pulse width modulator. The output of the pulse width modulator controls the heater switch. It has been found that the heaters, with controlled duty cycle, operating in recycle periods of less than ten seconds, have a smooth, continuous heat output proportional to the duty cycle of the control signal.

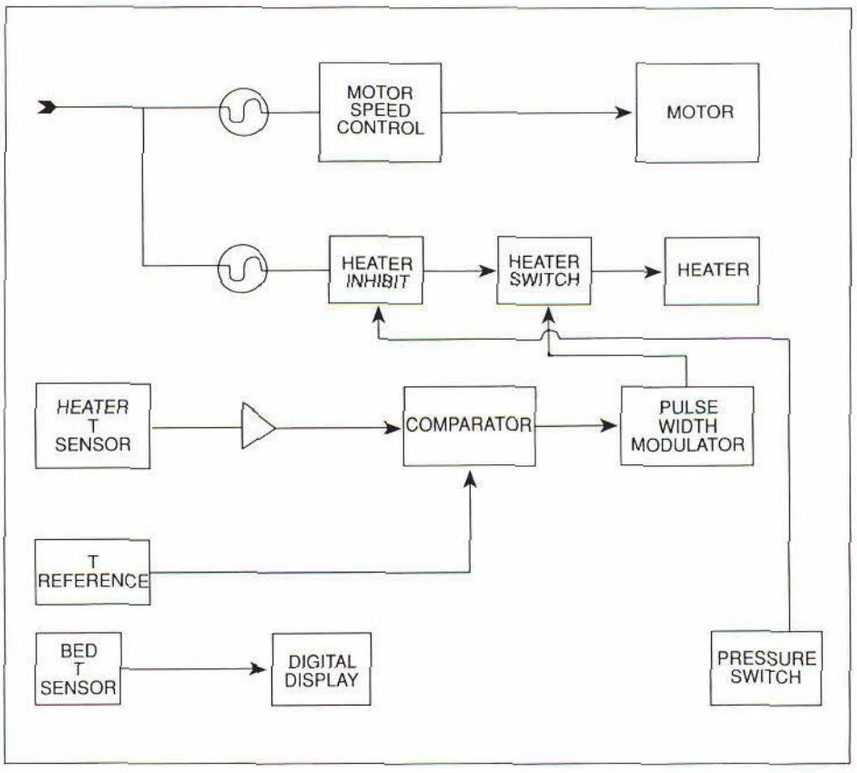

Figure 2
The Control and Measurement System

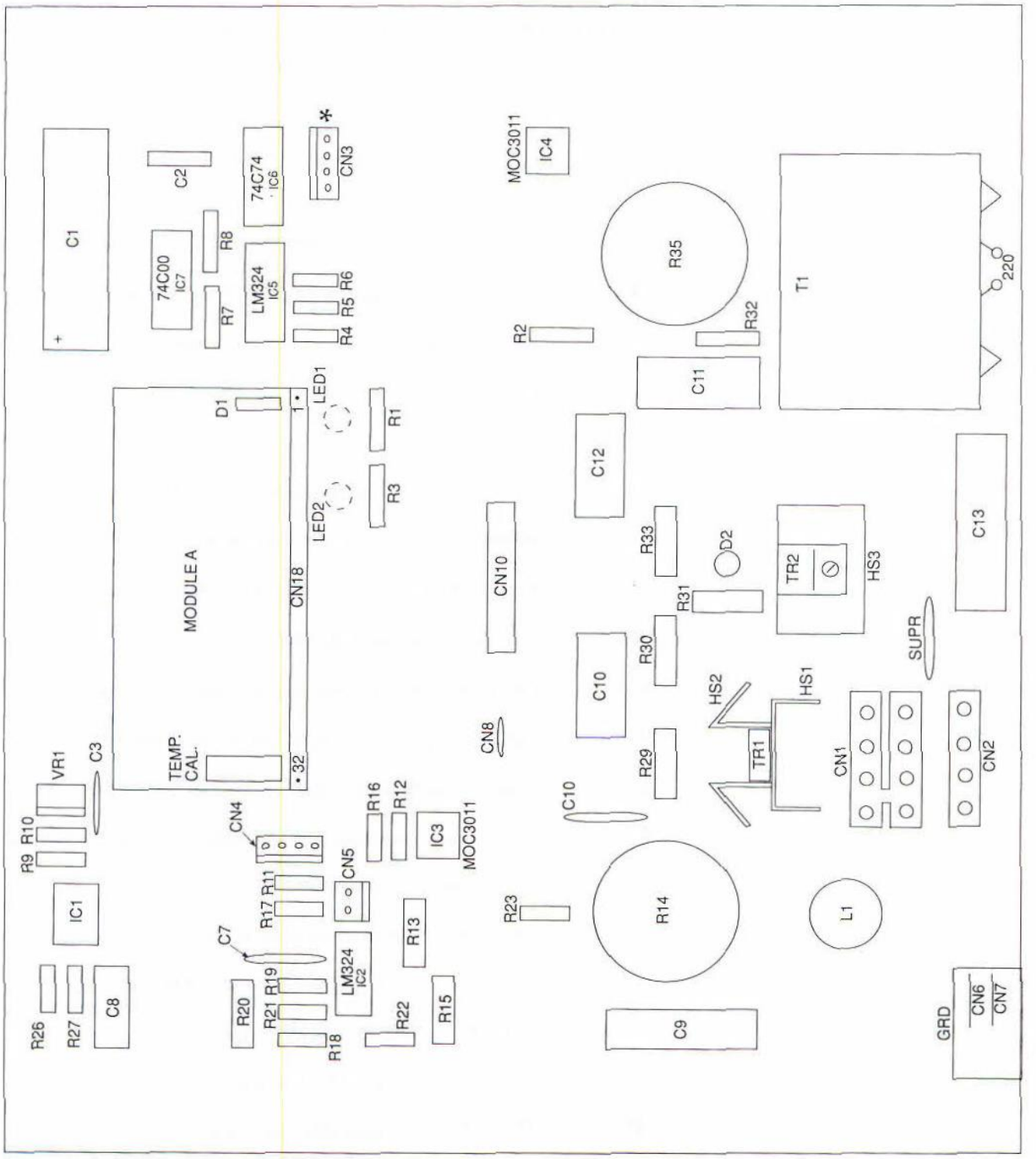

Figure 3
Parts Placement Diagram

* CN3 is located on Module A in latest style PCB.

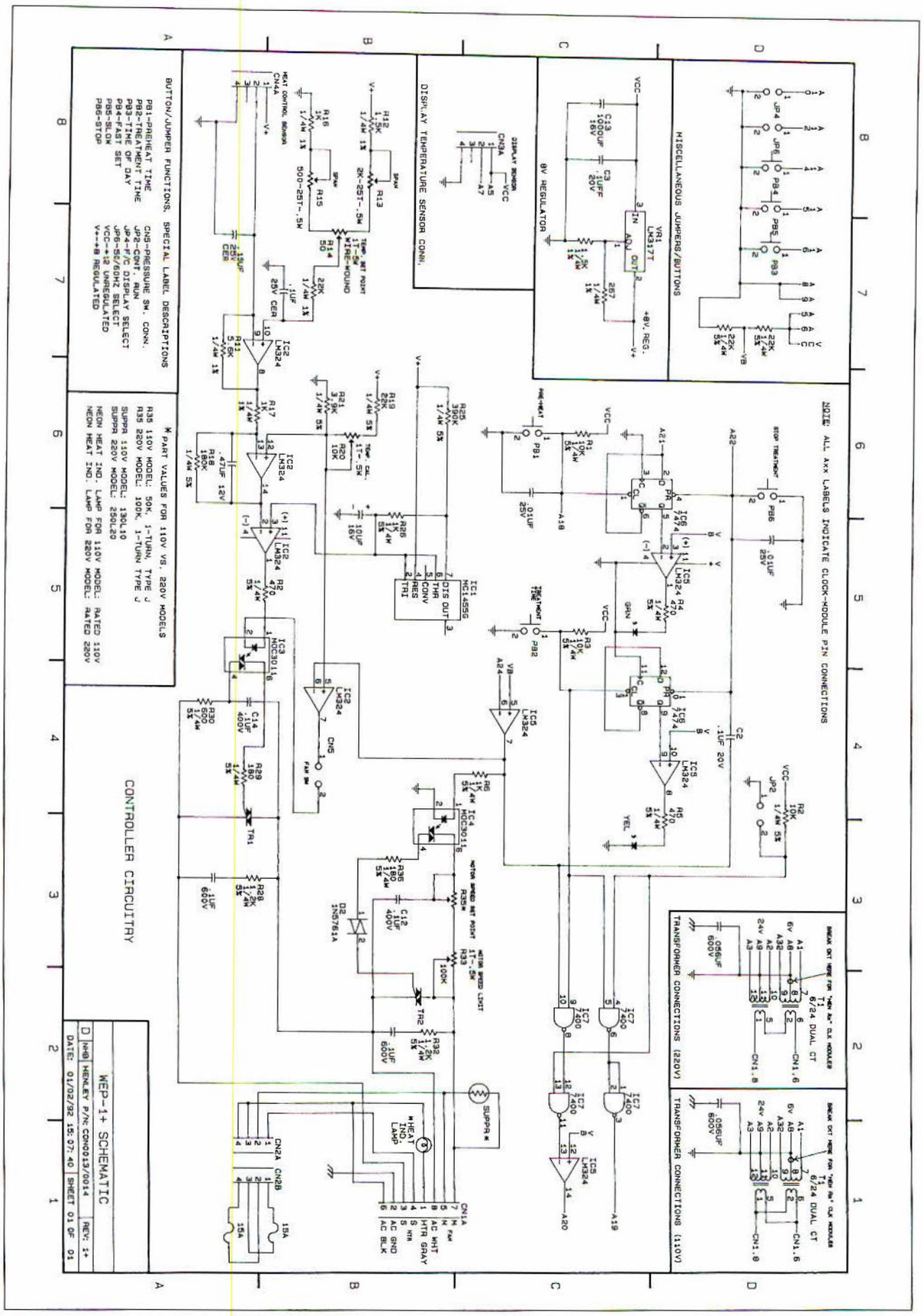

Figure 4
Circuit Diagram WEP1+ Controller

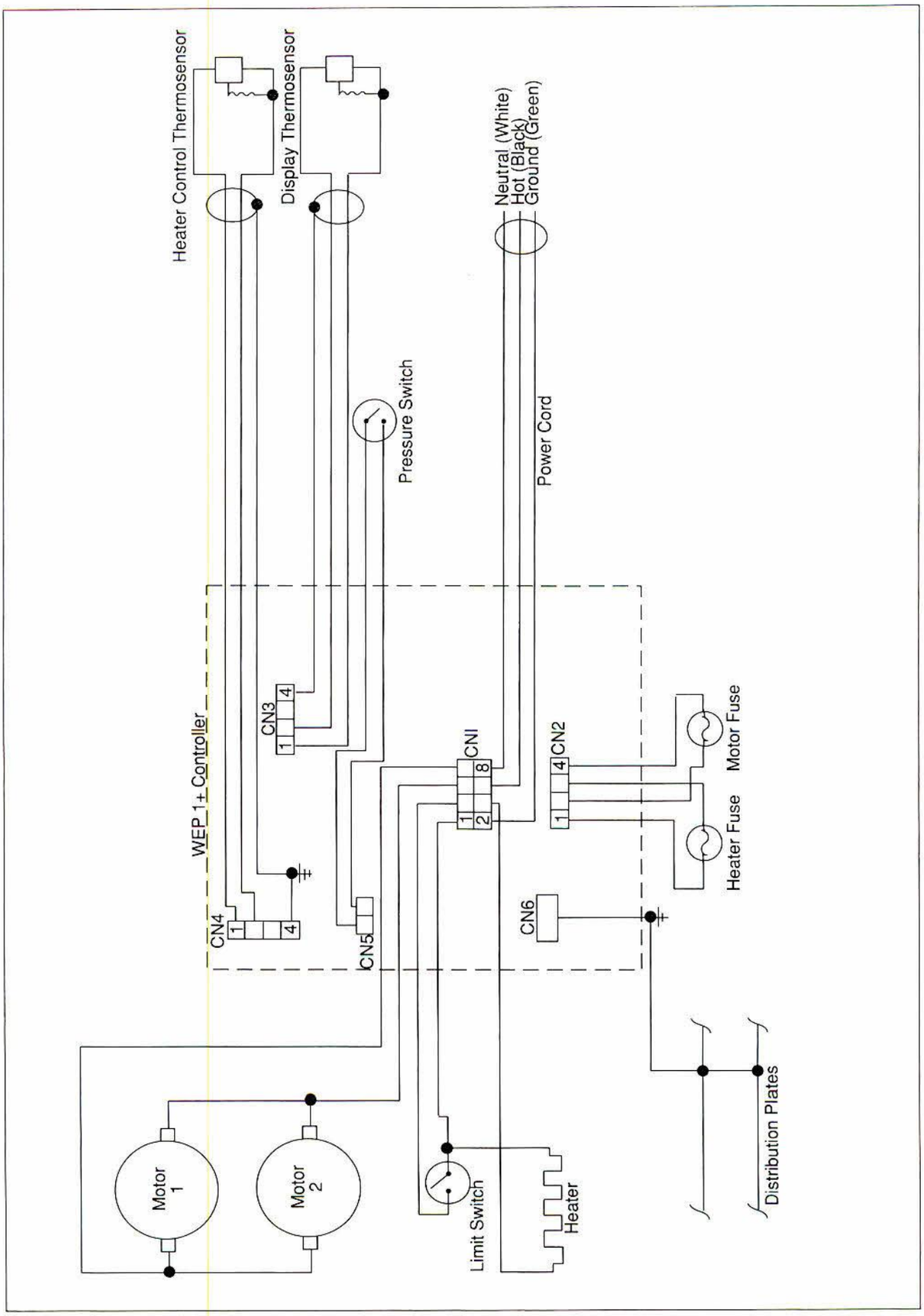

Figure 5
Fluidotherapy Wiring Diagram